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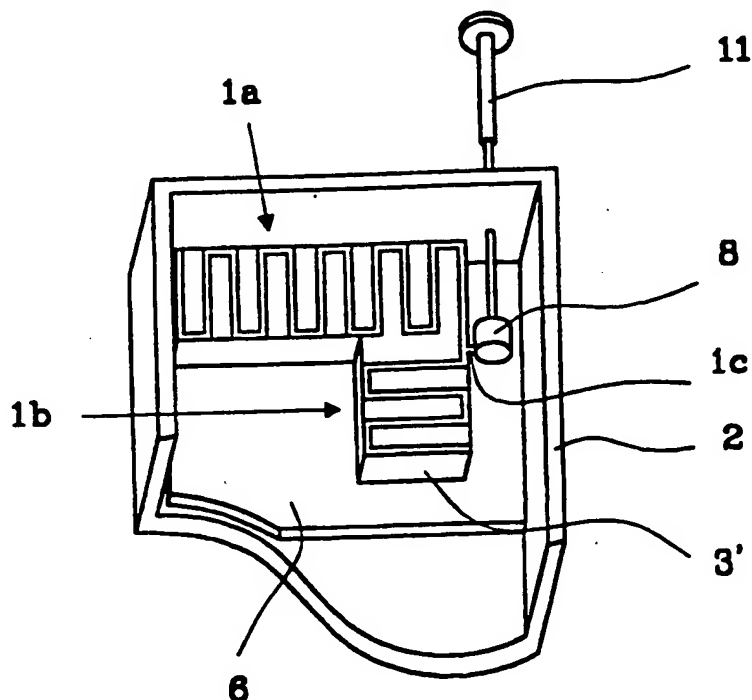
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(54) Title: ANTENNA DEVICE FOR A HAND-PORTABLE RADIO COMMUNICATION UNIT

(57) Abstract

An antenna device for a hand-portable radio communication unit including a casing with a ground plane means cooperating with the antenna device. The antenna device comprises first and second radiating elements (1a, 1b) being tuned to different resonant frequencies and having a common feed point (1c). The radiating elements (1a, 1b) are disposed in a compact arrangement on a support means (3) so as to be confined entirely in the casing (2).



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Antenna device for a hand-portable radio
communication unit

FIELD OF THE INVENTION

5 The present invention relates to an antenna device for a hand-portable radio communication unit, in particular a mobile telephone, including a casing, in which a ground plane means having at least one edge is disposed. The antenna device comprises first and second radiating elements carried by
10 support means, and said first and second radiating elements being tuned to different resonant frequencies.

BACKGROUND OF THE INVENTION

15 Such an antenna device is disclosed in the international patent application PCT/SE97/01046 (Allgon AB), wherein an embodiment shown in figure 3A includes first and second radiating elements in the form of flat meander-configured elements disposed on a flexible film carrier which is bent
20 into a cylindrical shape. The cylindrical support means with the first and second meander elements are arranged as a cylindrical or somewhat conical element projecting upwards from a top portion of the telephone casing adjacent to a corner thereof. As is also generally known per se, the known
25 antenna device includes a whip or rod antenna element, which is mechanically supported centrally in the projecting element and is movable between an operative extended position and a non-operative retracted position.

30 Thus, the previously known antenna device is basically located outside the casing as indicated above.

With this background, a main object of the present invention is to provide a compact antenna device which can be disposed
35 substantially inside the casing so as to avoid any outwardly

projecting sleeve or conical member, except for a possible extendable whip or rod antenna element. It is also desirable to make the whole radio communication unit or mobile telephone compact by such a measure.

5

Another object is to provide an antenna device having a low weight.

10 Still another object is to provide an antenna element having a satisfactory efficiency and bandwidth for each frequency in spite of a low volume of the device. The performance should be at least as good as for a conventional, stationary helix antenna.

15 Still another object is to provide a built-in antenna device, which can be manufactured in large series at low costs.

Still another object is to provide an antenna element also provided with a rod having a reduced total length (for a given
20 radiating length).

SUMMARY OF THE INVENTION

According to a first aspect of the invention the main object
25 stated above is achieved for an antenna device having the features stated in appended claim 1. Thus, the first and second radiating elements, each being tuned to a specific resonant frequency, are disposed in a compact arrangement on a support means, which is adapted to be mounted with the first
30 and second radiating elements located in proximity of, i.e. adjacent to, one or two edges of the ground plane means so as to be confined entirely in the casing. The two radiating elements preferably extends with their longitudinal axes substantially in parallel to said one or two edges.

35

In a preferred embodiment, wherein the casing is shaped substantially as an elongated box with the antenna device located adjacent to an end portion thereof, the support means, together with the first and second radiating elements, is
5 dimensioned so as to extend transversely between the opposite longer sides of the elongated box constituting the casing.

Thus, the first and second radiating elements are confined entirely in the casing. However, it is possible to combine
10 these first and second radiating elements with a third radiating element in the form of a whip or a rod, which is connectable to a feed point of the radiating elements so as to be coupled electrically in parallel to the first and second radiating elements. Preferably, the rod is movable between an
15 operative extended position, located at least partially outside the casing, and a retracted position, located substantially inside the casing.

The first and second radiating elements are preferably
20 constituted by flat substantially meander-configured elements or flat elongated substantially straight elements, whereby the weight of the antenna device can be kept very low. However, it is also possible to use helical elements.

In one preferred embodiment said first and second elements are
25 located on mutually perpendicular sides of said support means.

These and other preferred features of the invention are stated in the dependent claims 2-19 and will appear from the detailed description below.

30

According to a second aspect of the invention, the main object stated above is achieved for an antenna of device having the features stated in any one of claims 20 - 22, i.e. with a rod

element in combination with at least one internal radiating element having multiple turns.

This geometry may generally allow an arrangement wherein the rod element and the internal element have a relatively small electromagnetic interaction.

The invention also concerns a radio communication unit comprising an antenna device as defined in any one of the claims 1 - 22.

10

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be explained more fully with reference to the appended drawings which illustrate some preferred embodiments.

15

Fig. 1 shows, schematically, in a perspective view from the rear, a telephone casing with an interior antenna device according to the invention, the rear wall of the telephone casing being taken away for clarity;

20

Fig. 2 shows, in a corresponding perspective view, a casing with a modified antenna device including a rod in an extended position;

25

Fig. 3 shows the casing of fig. 2 with the rod in a retracted position;

Fig. 4 shows the antenna device of fig. 1, including a rectangular ground plane means;

30

Fig. 5 shows a modified embodiment of the antenna device of fig. 4;

Fig. 6 shows, likewise schematically and in a perspective view, a second embodiment of the antenna device according to the invention;

5 Fig. 7 shows, in a corresponding perspective view, a third embodiment of the antenna device;

Fig. 8 shows, in a corresponding perspective view, a fourth embodiment of the antenna device;

10 Fig. 9 shows, in a corresponding perspective view, a fifth embodiment of the antenna device;

Fig. 10 shows, in a corresponding perspective view, a sixth embodiment of the antenna device;

Fig. 11 shows, in a larger perspective view, the antenna device shown in figs. 1 and 4, including a support body;

20 Fig. 12 shows, in a planar view, a plastic foil member with a meander-configured antenna device similar to the one shown in figs. 1, 4 and 11;

Fig. 13 shows a meander element similar to the one shown in fig. 7;

Figs. 14 and 15 show schematically modified embodiments of the meander element shown in fig. 13.

Fig. 16 shows an antenna element according to a seventh preferred embodiment of the invention.

30 Fig. 17 shows an antenna element according to an eighth preferred embodiment of the invention with different feed points for different radiating elements.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

With reference to figs. 1, 4 and 11, there is shown a first,
5 basic embodiment of the antenna device according to the invention, the antenna device 1 being disposed in one end portion of an elongated, box-like casing 2 of a hand-portable mobile telephone. All parts of the telephone as such, including its electronic circuitry, are left out from fig. 1,
10 even the rear wall of the casing. Of course, the casing 2 is normally designed with smooth corners and a general shape making the telephone unit visually pleasant and convenient to hold in one hand by the user.

15 According to a first aspect of the present invention, the antenna device 1 comprises first and second radiating elements 1a, 1b carried by a support means 3, which in this embodiment is formed by a straight bar 3 constituted by a hollow, molded body of plastic material, such as polypropene or teflon,
20 whereby the weight of the antenna device will be low. The bar 3 extends transversely between the opposite longer sides 2a, 2b of the casing 2 and can be snapped into the shown position.

The antenna elements 1a and 1b are constituted by flat
25 meander-configured elements of an electrically conductive material, normally a metal material such as aluminium or copper. Although the meander element is shaped as a continuous meander element, there are two radiating elements 1a and 1b extending from a common feed point 1c in opposite directions
30 to a respective free end 1aa, 1bb (fig. 11). The two radiating elements 1a, 1b are tuned to different resonant frequencies allowing operation of the antenna device in two overlapping or separated frequency bands, for example 900 MHz and 1,8 GHz. The common feed point 1c is to be connected to a feeding
35 circuitry of the telephone.

A convenient way of mounting the meander-configured radiating elements 1a, 1b onto the support body 3 is to use a plastic foil, which is securable onto the support body 3 by means of an adhesive agent. Preferably, as shown in fig. 12, the plastic foil is provided with flap portions along at least two of its edges, preferably along all four edges, whereby the flap portions can be folded onto the side walls of the molded support body 3. If desired, an impedance matching circuit 5 may be disposed on one or more of the flap portions 4a.

Each one of the meander radiating elements 1a, 1b has a length of approximately $\lambda/4$, λ being the respective wave length of the high frequency radiation, each radiating element cooperating with a ground plane 6, e.g. in the form of a metal layer on a dielectric substrate. Preferably, as will be apparent from figs. 1 and 4, the ground plane means 6 is extended over the whole area of the casing 2. However, it is not strictly necessary that the ground plane means is extended all the way underneath the antenna device 1. Such a modified embodiment is shown in fig. 5.

According to a further aspect of the invention, as illustrated in fig. 11, a protective device in the form of an electrically resistive layer 7 is mounted on the lower side of the support body 3 for absorbing electromagnetic radiation, which is transmitted from the two meander radiating elements 1a, 1b towards a part of the casing 2 which is designed to be held against the user's head.

Preferably, such a protective layer is constituted by a very thin metal layer, e.g. of aluminium, with a thickness in the order of 10-100 nm. Generally, such a protective layer should be positioned between a part of the casing being designed to be located adjacent to a body portion of a human being, on the

one hand, and the radiating elements 1a, 1b, on the other hand.

Without being specifically mentioned, a protective layer of
5 this kind can be arranged in all embodiments to be described further below.

Fig. 2 shows an embodiment, which is exactly like the one in
fig. 1, except for the fact that a third radiating element in
10 the form of a whip or rod 11 is added, the antenna rod 11
being connected at the common feed point 1c, i.e. electrically
in parallel to the meander radiating elements 1a and 1b. As is
known per se, the rod 11 is movable between an operative
extended position, located at least partially outside the
15 casing 2 (as shown in fig. 2), and a non-operative retracted
position, located substantially inside the casing 2, as shown
in fig. 3. The rod 11 is guided mechanically in a short sleeve
member 8.

20 In a second embodiment of the antenna device, as shown in fig.
6, the meander-configured radiating elements 1a and 1b are
mounted on a L-shaped support body 3', the first meander
radiating element 1a being oriented with its longitudinal axis
along one edge (the shorter edge) of the rectangular ground
25 plane means 6, and the other meander radiating element 1b
being oriented with its longitudinal axis adjacent and in
parallel to the adjacent, longer edge of the ground plane
means 6.

30 In this case, the common feed point 1c is located relatively
close to the upper corner of the elongated box-like casing 2.
So, an extendable antenna rod 11 can be conveniently located
in this corner region, as is also apparent from fig. 6.
Although not shown specifically, the antenna rod 11 can be

retracted fully into the casing upon being slid through the sleeve 8 at the common feed point 1c.

5 In a third embodiment shown in fig. 7, two meander-configured radiating elements 1a and 1b are mounted onto the upper, shorter end wall 2c of the casing 2. The elements 1a, 1b can be mounted either directly onto the inside of the casing wall 2c, serving as a support means, by means of a printed circuit board or by the intermediary of a plastic foil similar to the
10 one shown in fig. 12, preferably with only one, two or three flap portions.

In this case as well, the first and second radiating elements 1a, 1b have a meander-like pattern with multiple turns along a
15 respective longitudinal axis from a common feed point 1c. The elements 1a, 1b extends with their respective longitudinal axes in parallel to the shorter edge of the rectangular ground plane means 6, with which the radiating elements cooperate. In this embodiment as well, a retractable antenna rod 11 can be
20 mounted in a guiding sleeve 8 at the common feed point 1c. As appears from fig. 7, in this third embodiment, the meander elements 1a, and 1b are located in a plane which is perpendicular to the ground plane means 6.

25 The exact configuration of the meander elements 1a, 1b may be modified in various ways, some of which are shown in figs. 13, 14 and 15, all these meander configurations being intended to be mounted at the inside of the casing wall 2c shown in fig. 7. In figs. 13-15, the small circle represents the guiding
30 sleeve 8 located at the common feed point 1c.

In a fourth embodiment illustrated in fig. 8, the meander-configured elements are replaced by helical elements 21a, 21b extending from a common feed point 21c to a respective free
35 end.

In this case, the supporting means has the form of a box member 9 which holds the two helical elements 21a and 21b mechanically and in which these elements are electrically
5 connected to the common feed point, which has the form of a downwardly projecting tab 21c to be connected to the feeding circuitry (not shown) located above the ground plane means 6. Like in the embodiments shown in figs. 1-5 and fig. 7, the longitudinal axes of the helical elements 21a, 21b extend in
10 parallel to the shorter edge of the rectangular ground plane means 6. There is also an optional retractable antenna rod 11 guided in a sleeve inside the element holder 9.

In a fifth embodiment shown in fig. 9, there are also two
15 helical radiating elements 21a and 21b supported by a holding box 9, the difference from fig. 8 being that the ground plane means 6 is not extended all the way to the end wall 2c of the casing. So, the longitudinal axes of the helical elements 21a 21b are located substantially in the same plane as the ground
20 plane means 6. There is also a rod antenna 11, shown in its retracted position.

Finally, fig. 10 illustrates a sixth embodiment of the antenna device, including two helical elements 21a, 21b, located above
25 the ground plane means 6. Here, the first helical 21a is oriented with its longitudinal axis in parallel to the shorter edge of the ground plane means 6, whereas the other helical element 21b is oriented with its longitudinal axis in parallel to the longer edge of the ground plane means 6.

30

The two helical elements 21a, 21b are securely held by a supporting box element 9 in the adjacent inner corner of the casing 2, a retractable rod 11 being also supported by the box
35 element 9.

In the embodiments with helical elements 21a, 21b shown in
figs. 8-10, a thin, dielectric sleeve is preferably disposed
around each helical coil so as to provide an improved
mechanical stability. Matching circuitry may be arranged on
5 the printed circuit card carrying the ground plane means 6.

In all illustrated embodiments, the meander or helical
elements will provide a substantially omnidirectional
radiation pattern.

10 Furthermore, and most importantly, the particular location and
orientation of the dual radiating elements 1a, 1b and 21a, 21b
respectively, enable a very compact arrangement of the main
antenna device totally inside the telephone casing, especially
15 when the radiating elements are supported by a hollow plastic
body. It is also convenient to mount the antenna device into
the casing, e.g. by a snap fit, and it is therefore suitable
for mass production at low cost.

20 Thanks to the protective layer 7 (fig. 11), the antenna device
can be operated with relatively high power in spite of the
location of the antenna device inside the casing. In some
embodiments, e.g. the one shown in fig. 7, the protective
layer 7 is preferably mounted directly onto the casing wall,
25 preferably at the inside thereof.

Of course, the antenna device may comprise more than two
internal radiating elements extending from a common feed point
and each being tuned to a particular resonant frequency.

30 Moreover, according to a second aspect of the invention, the
antenna device may include only one internal radiating element
with multiple turns, e.g. a meander element such as the
element 1a in fig. 6 or a helical element such as the element
35 21a in fig. 10, in combination with a rod element 11 being

perpendicular to the longitudinal axis of the internal element with multiple turns.

Whenever a rod element 11 is used, it may be positioned in the same plane as the ground plane means 6, or it may be disposed in parallel above or below the ground plane means 6 at a suitable vertical distance therefrom.

Figure 16 shows another preferred embodiment according to the invention. A support means is denoted 1601 and a ground plane is denoted 1602. A first radiating element is denoted 1603 and comprises a first patch 1604, a meander shaped portion 1605 and a second patch 1606. The first radiating element 1603 is in conductive contact with a capacitor member 1607 constituting a capacitive load with the ground plane 1602. In this way the antenna means can be made more compact for a given resonance frequency, generally however with some trade-off in gain and relative bandwidth.

A second radiating element is denoted 1608 and is in the form of an elongated straight conductive line. Said first and second radiating elements 1603 and 1608 are in conductive contact with a common feed point 1609. A hole in the support means 1601 enables a rod or whip antenna (not shown) to be connected to the feed point 1609. The rod or whip antenna may be coupled capacitively, inductively or conductively to the feed point 1609. A matching circuit, is denoted 1610 and is used for matching the antenna means to the feeding circuitry schematically shown in figure 16 and denoted 1611. The matching circuit 1610 is mounted on one side of the support means 1601 and connected between said second radiating element 1608 and said ground plane 1602.

The matching circuit 1610 may also comprise a balun, which balances the currents, reducing currents in the ground plane and thereby enabling SAR reduction.

The conductive portions, such as the radiating elements, feed point etc, on the support means may be molded or coated directly onto the support means thus eliminating the need for a carrier to be adhered to the support. This can be achieved
5 by molding the radiating portions directly onto the support 1601 using MID (molded interconnection device) techniques. The use of MID technology would simplify mounting of the matching circuit 1610 to the support 1601 since no separate thin plastic carrier is used for the radiating portions. Such
10 plastic carrier may melt or otherwise be damaged in the process of mounting the matching circuit, balun or antenna itself.

The use of the first and second patches 1604 and 1607 enables a generally larger and/or dual bandwidth and improved gain
15 compared to a meander pattern without such patches.

The support means is soldered, screwed, snapped or in any other way known in the art mounted on the ground plane 1602. One further alternative, which is believed to be novel, is using an adhesive tape to mount said support on the PCB. The
20 tape may be completely, partly or not at all conductive.

In figure 17 is another preferred embodiment shown and with 1701 is a support means denoted and with 1702 is a ground plane denoted. A first radiating element is denoted 1703 and a second radiating element is denoted 1704. A first feed point, denoted 1705, is arranged for feeding RF signals from a
25 circuitry, schematically shown in figure 17 and denoted 1706, to said first radiating element 1703. A second feed point denoted 1707 is arranged for feeding RF signals from said circuitry 1706 to said second radiating element 1704. The
30 support means 1701, in this preferred embodiment, is securely fixed using a thin tape provided with an adhesive agent on two sides.

Claims:

1. Antenna device for a hand-portable radio communication unit including a casing (2), in which a ground plane means (6) having at least one edge is disposed, said antenna device comprising:
 - 5 - first and second radiating elements (1a, 1b) carried by a support means (3),
 - said first and second radiating elements being tuned for different resonant frequencies,
 c h a r a c t e r i z e d b y
 - 10 - said first and second radiating elements (1a, 1b) being disposed in a compact arrangement on said support means (3) and extending from at least one feed point along a longitudinal axis to a first and a second free end (1aa, 1bb), respectively, and
 - 15 - said support means being adapted to be mounted with said first and second radiating elements located adjacent to said at least one edge of said ground plane means (6) so as to be confined entirely in said casing (2).
2. Antenna device as defined in claim 1, wherein said casing
20 (2) is shaped substantially as an elongated box with the antenna device (1) located adjacent to an end portion thereof and wherein said support means (3), together with said first and second radiating elements (1a, 1b), is dimensioned so as to extend transversely between opposite
25 longer sides (2a, 2b) of the elongated box constituting the casing (2).
3. Antenna device as defined in claim 1 or 2, wherein each of
30 said first and second radiating elements is adapted to extend with its longitudinal axis substantially in parallel to an associated one of said at least one edge.

4. Antenna device as defined in any of claims 1-3, wherein said first and second radiating elements are fed with RF signals from a common feed point (1c).
5. Antenna device as defined in any of claims 1-3, wherein said first and second radiating elements are fed with RF signals from a first and second feed point (1705, 1707), respectively.
6. Antenna device as defined in any of claims 1-5, wherein said support means (3) comprises a first and a second side being mutually perpendicular, and
 - said first and second radiating elements being arranged on said first and said second side, respectively.
7. Antenna device as defined in claim 6, wherein said support means (1601) further comprises a third side being perpendicular to said first and second sides,
 - a first conductive part (1607) being arranged on said third side in conductive contact with one end of said first or second radiating element, and
 - said first conductive part extending towards said ground plane means (6) so as to construe a capacitance.
8. Antenna device as defined in any of claims 1-7, wherein each of said first and second radiating element extends in a pattern with multiple turns along a longitudinal axis to a first and a second free end (1aa, 1bb).
9. Antenna device as defined in any of claims 1-8, wherein at least one of said first or second radiating elements comprises a first patch, an adjoining a meander shaped portion (1605) and an adjoining second patch (1606).

10. Antenna device as defined in any of claims 1-9, wherein one of said first or second radiating elements is a straight elongated conductive element.
- 5 11. Antenna device as defined in any of claims 1-10, wherein a third radiating element (11) comprising a rod is connectable to said common feed point (1c) so as to be coupled electrically in parallel to said first and second radiating elements (1a, 1b).
- 10 12. Antenna device as defined in claim 11, wherein said rod (11) is movable between an operative extended position, located at least partially outside said casing, and a retracted position, located substantially inside said casing.
- 15 13. Antenna device as defined in any one of claims 1-12, wherein at least one of said first or second radiating elements is constituted by a flat meander-configured element (1a, 1b).
- 20 14. Antenna device as defined in any one of claims 1-12, wherein at least one of said first or second radiating elements are constituted by helical elements (21a, 21b).
15. Antenna device as defined in claim 13 or 14, wherein said first and second radiating elements (1a, 1b; 21a, 21b) are oriented in line with each other along one and the same edge of said ground plane means (6).
- 25 16. Antenna device as defined in claim 13 or 14, wherein said first radiating element (1a; 21a) is oriented in parallel to a first edge of said ground plane means (6), whereas said second radiating element (1b; 21b) is oriented substantially at right angle to said first element and in

parallel to a second, adjoining edge of said ground plane means (6).

17. Antenna device as defined in claim 13, wherein said flat meander-configured elements (1a, 1b) are located in a plane being substantially parallel to said ground plane means.
18. Antenna device as defined in claim 13, wherein said flat meander-configured elements (1a, 1b) are located in a plane being substantially perpendicular to said ground plane means.
19. Antenna device as defined in in any one of the preceding claims, wherein said support means is shaped like a bar.
20. Antenna device as defined in any one of the preceding claims, wherein said support means is constituted by a molded body (3) of plastic material.
21. Antenna device as defined in claim 20, wherein said molded body is hollow.
22. Antenna device as defined in in any one of the preceding claims, wherein said first and second radiating elements are mounted on a plastic foil (4) which is securable onto said support means (3) by means of an adhesive agent.
23. Antenna device as defined in claim 22, wherein said plastic foil (4) includes at least one flap portion (4a) along at least one of its edges.
24. Antenna device as defined in claim 23, wherein matching circuitry (5) is disposed on said at least one flap portion (4a).

25. Antenna device as defined in any of the preceeding claims, wherein at least one of said first and second radiating elements is molded directly onto said support.
26. Antenna device as defined in in any one of the preceding
5 claims, wherein matching circuitry (5) is disposed on said support means.
27. Antenna device as defined in in any one of the preceding claims, wherein said support means is securely fixed by means of using a two-side adhesive material.
- 10 28. Antenna device as defined in any one of the preceding claims, wherein said ground plane means (6) is an electrically conductive layer on a printed circuit board.
29. Antenna device, as defined in any one of the preceding
15 claims, wherein said ground plane means is a metal layer serving as a shielding means on the inside of said casing.
30. Antenna device as defined in any one of the preceding claims, wherein an electrically resistive layer (7) is
20 disposed in said casing (2) between a part of said casing being designed to be located adjacent to a body portion of a human being, on the one hand, and said first and second radiating elements, on the other hand, said electrically
resistant layer serving as a protective device for
absorbing electromagnetic radiation which is transmitted
from said first and second radiating elements towards said
25 part of the casing.
31. Antenna device for a hand-portable radio communication unit including a casing, in which a ground plane means (6) having at least one edge is disposed, said antenna device comprising at least one radiating element (1a; 21a) carried

by a support means (3) and extending along a longitudinal axis from a feed point (1c) to a free end (1aa), and a radiating rod element (11), which is connectable to said feed point (1c) so as to be coupled electrically in parallel to said at least one radiating element (1a; 21a), characterized in that said at least one radiating element (1a; 21a) carried by said support means is internal element located entirely in said casing (2) with its longitudinal axis oriented substantially in parallel to said one edge of said ground plane means (6), said longitudinal axis being perpendicular to said rod element (11).

32. Antenna device as defined in claim 31, wherein internal radiating element is constituted by a flat meander-configured element (1a).

33. Antenna device as defined in claim 31, wherein said internal radiating element is constituted by a helical element (21a).

34. Antenna device as defined in any of claims 30-32, wherein said internal element is extending in a pattern with multiple turns along an longitudinal axis from said feed point (1c).

35. A radio communication unit comprising an antenna device as defined in any one of the preceding claims.

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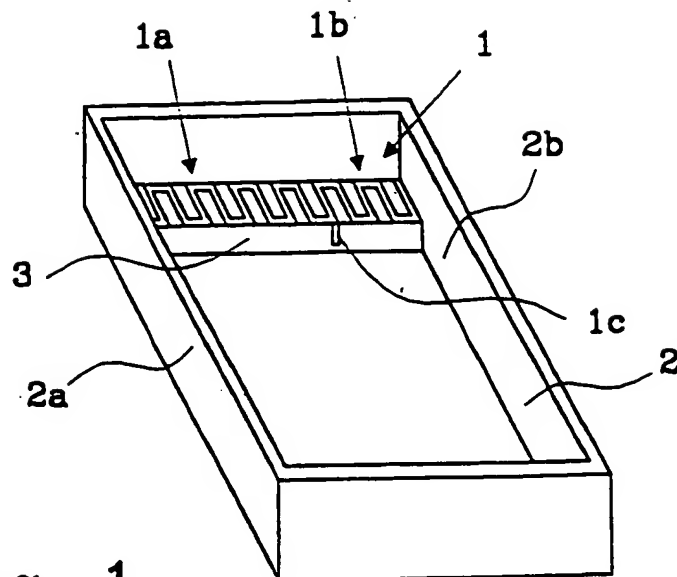


Fig. 1

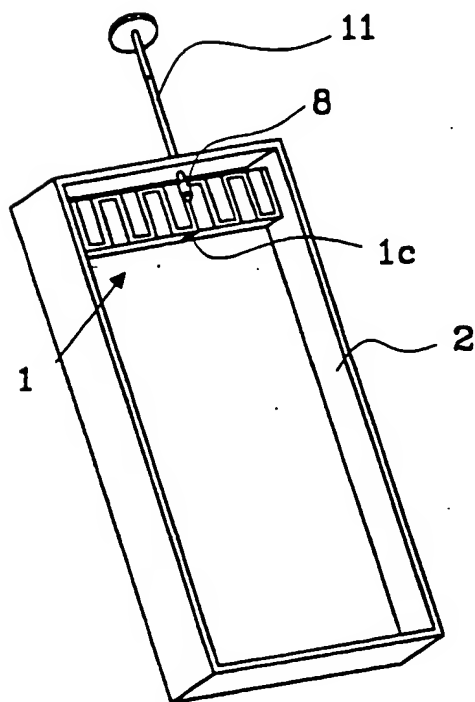


Fig. 2

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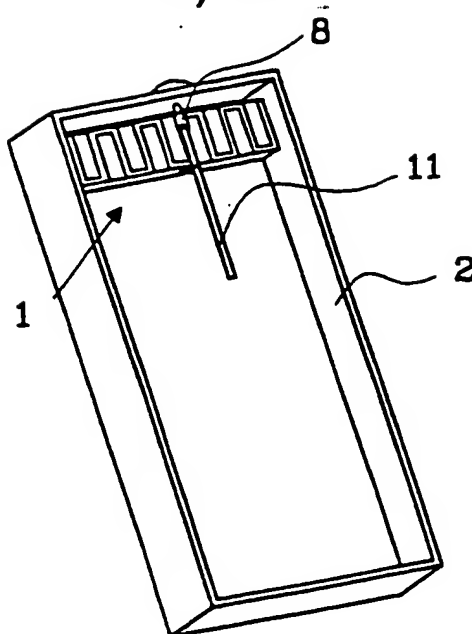


Fig. 3

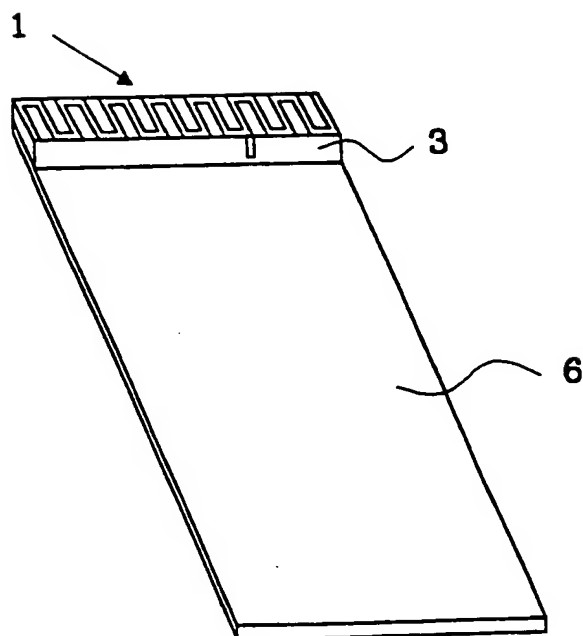


Fig. 4

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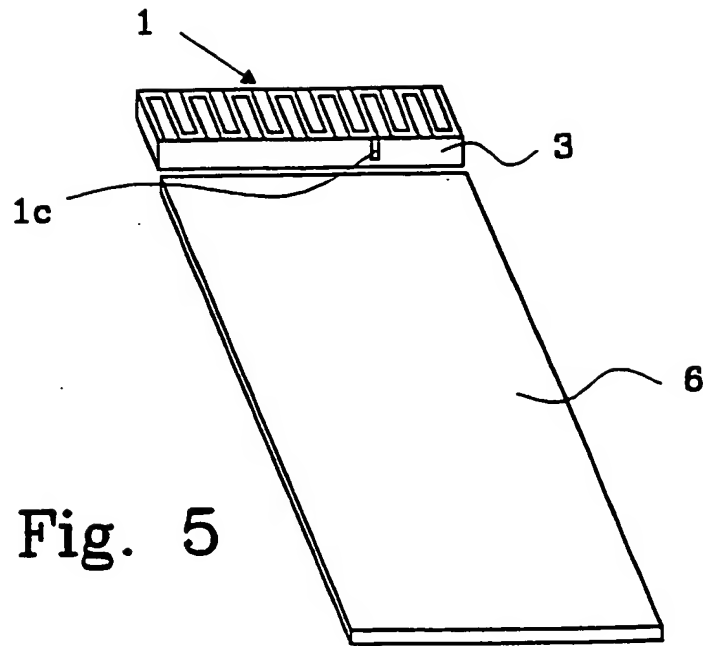


Fig. 5

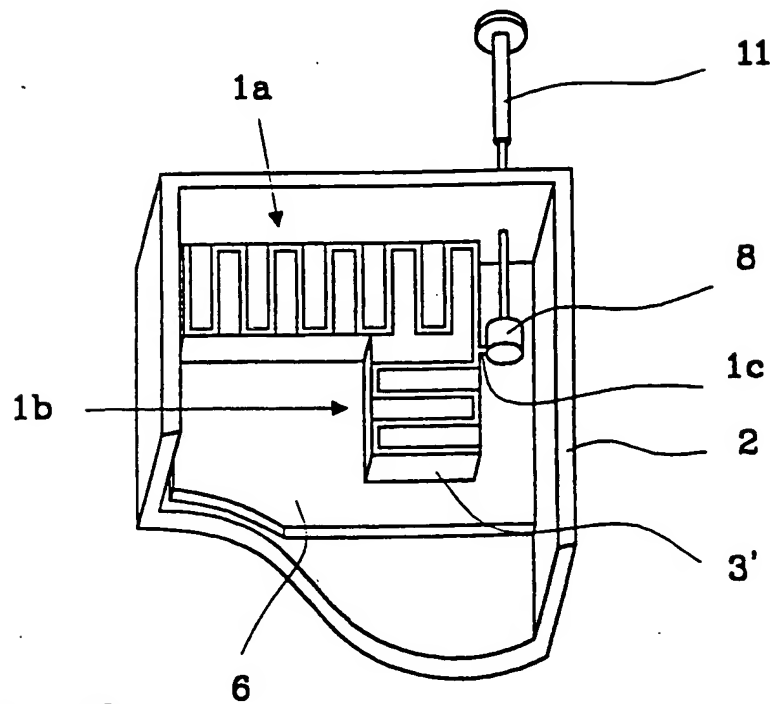


Fig. 6

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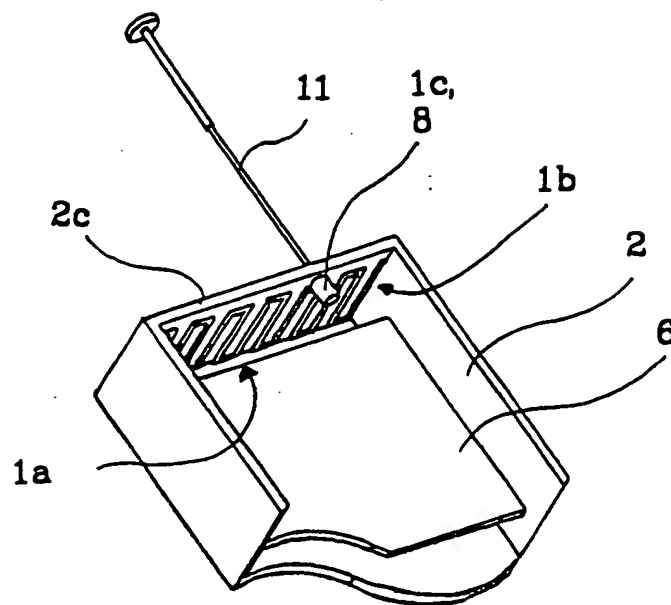


Fig. 7

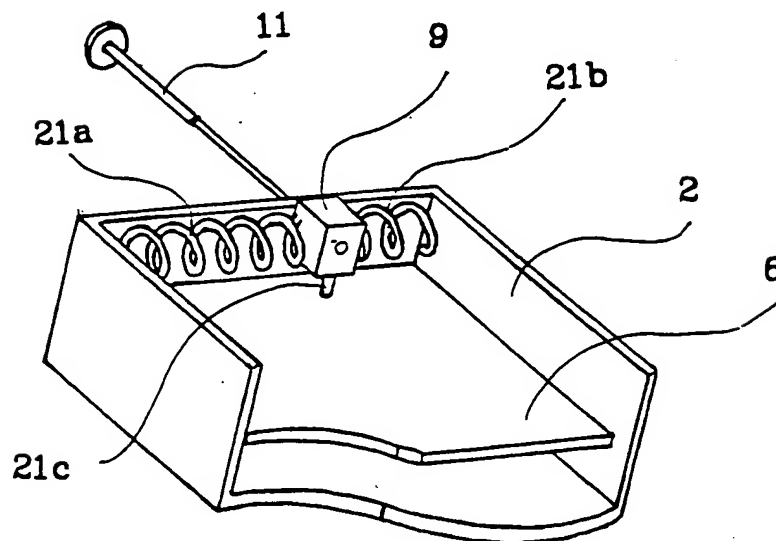


Fig. 8

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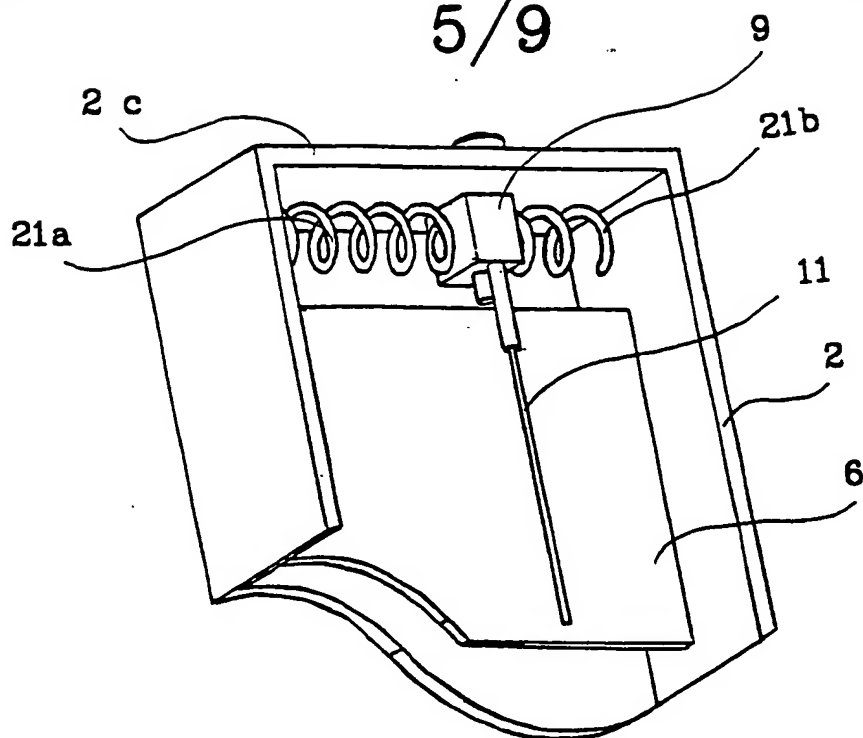


Fig. 9

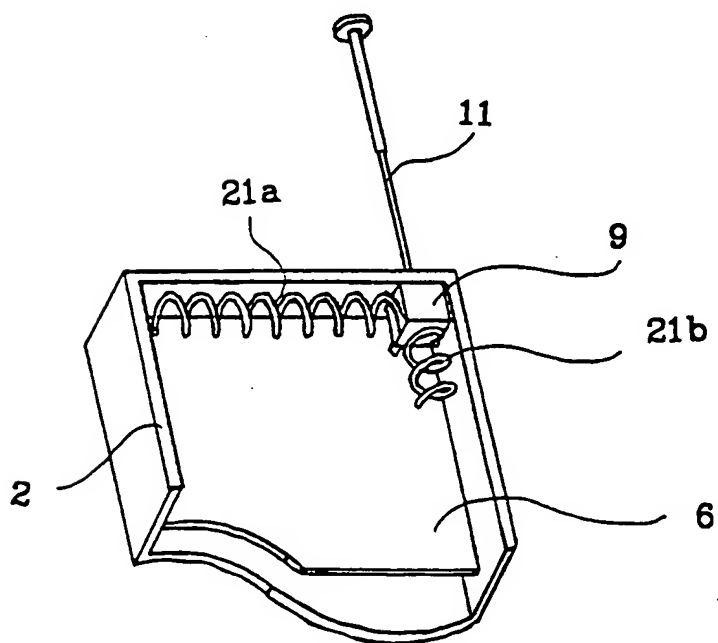


Fig. 10

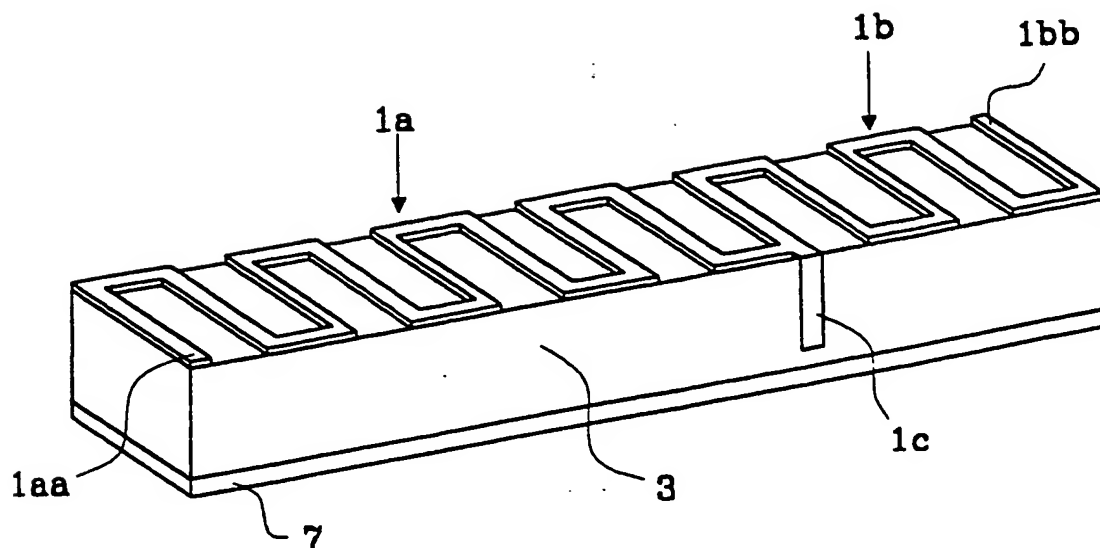


Fig. 11

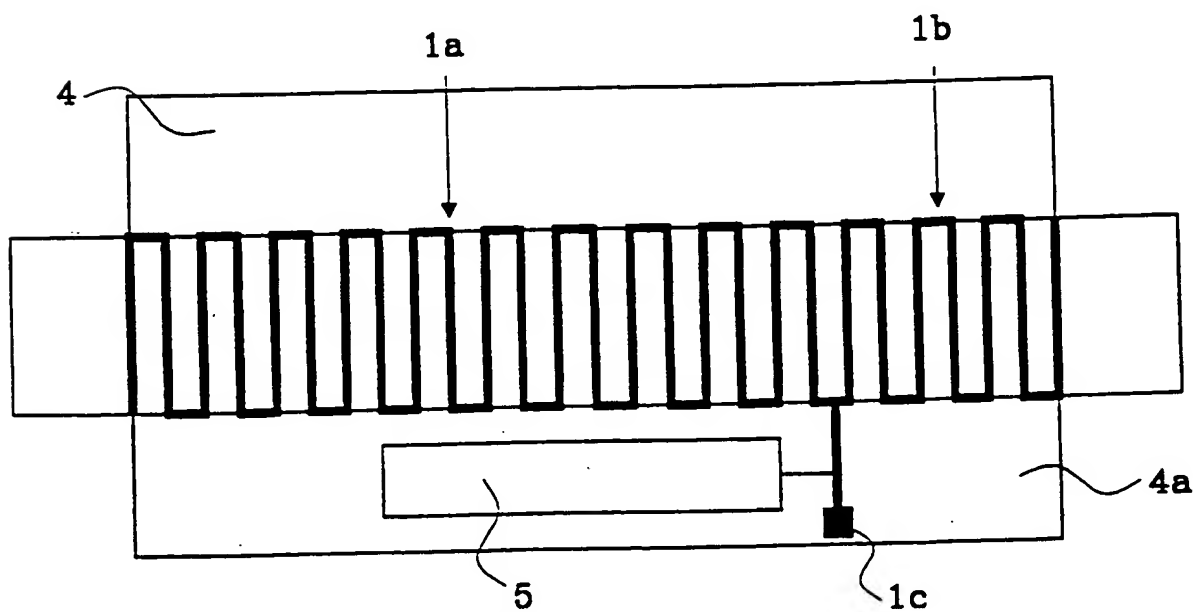


Fig. 12

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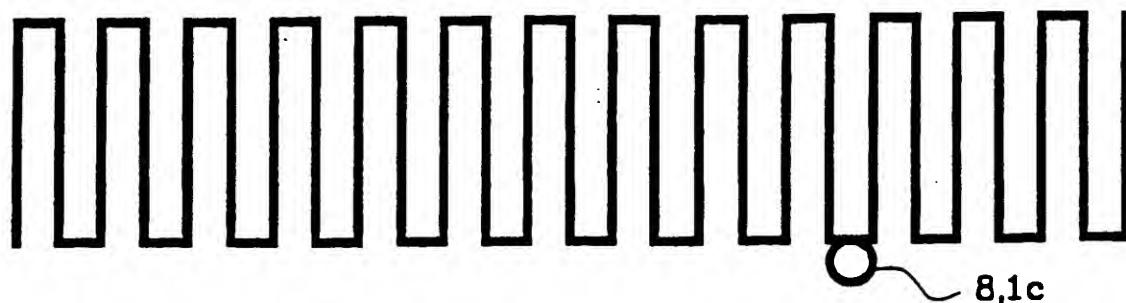


Fig. 13

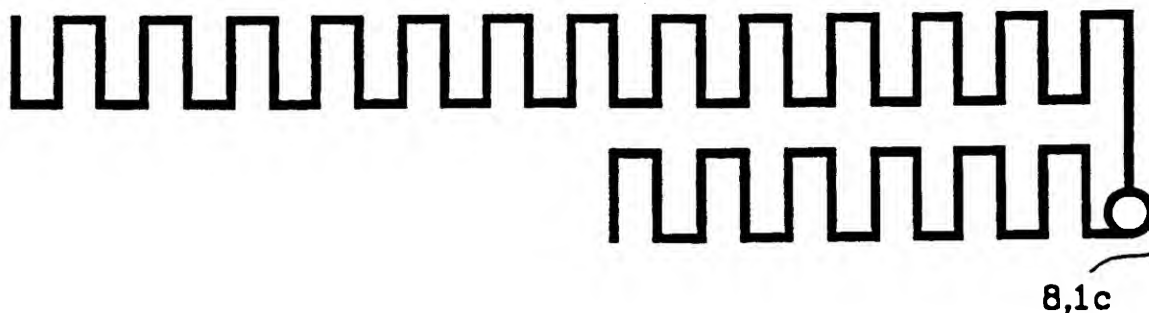


Fig. 14

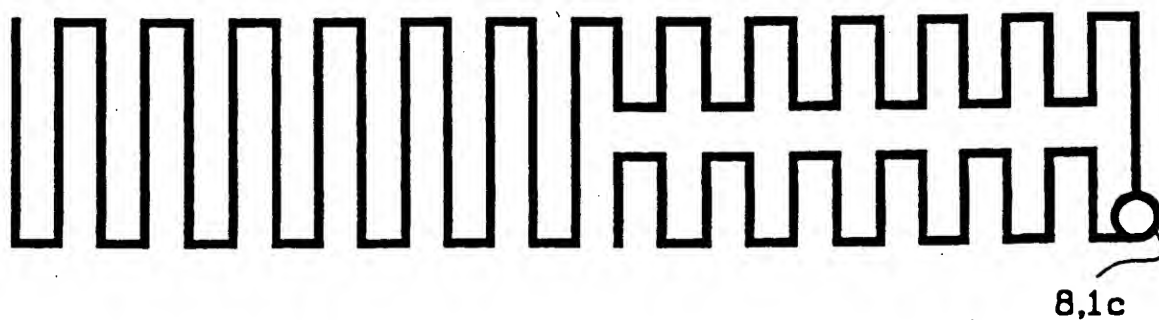


Fig. 15

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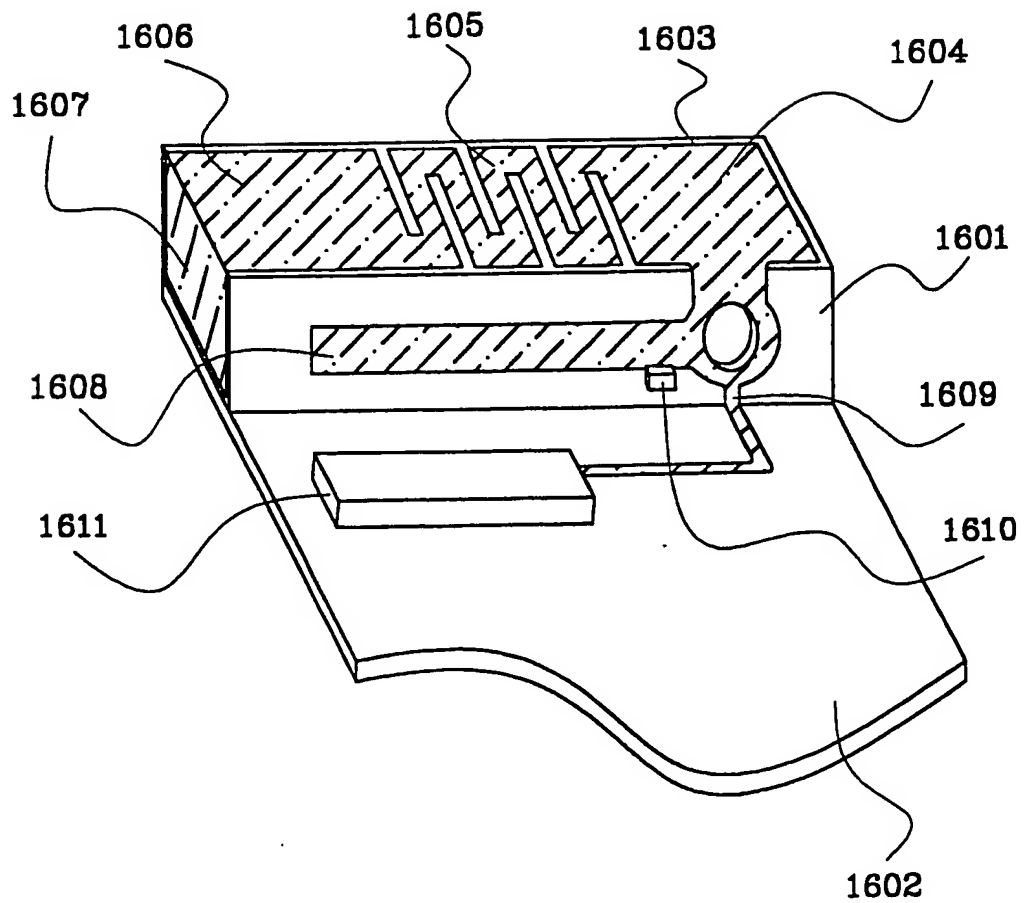


Fig 16

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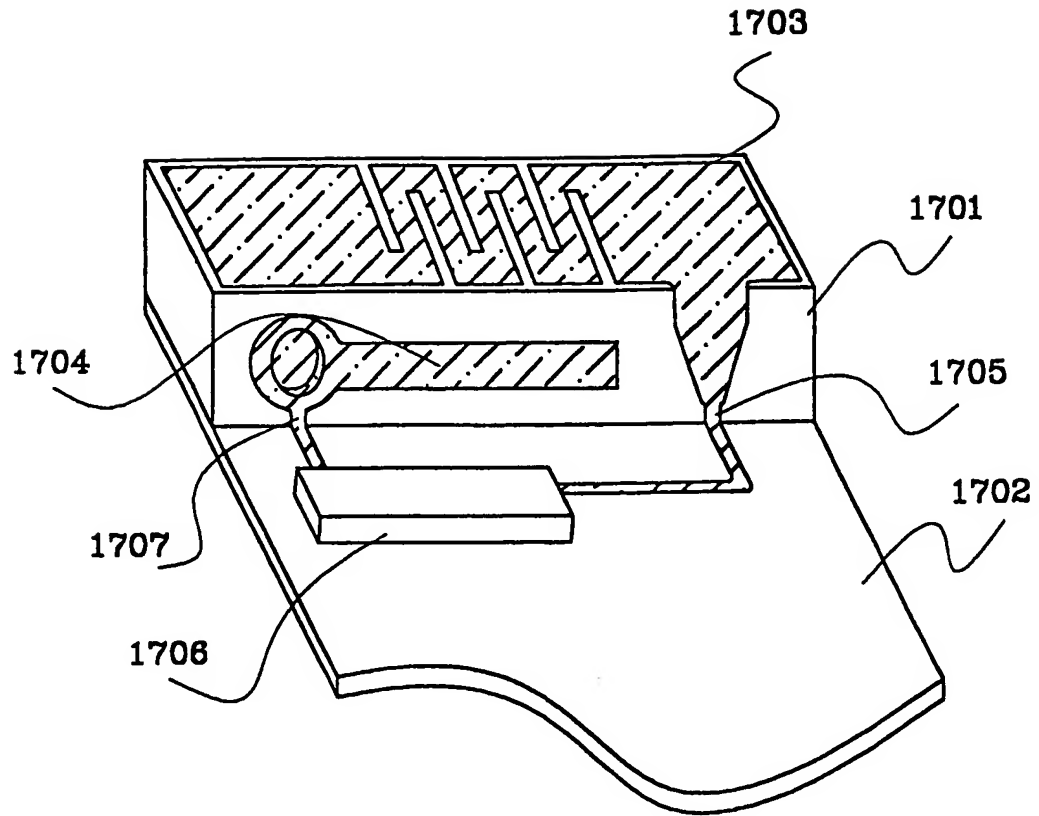


Fig 17

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 98/00899

| A. CLASSIFICATION OF SUBJECT MATTER | | |
|---|---|---|
| IPC6: H01Q 1/24 According to International Patent Classification (IPC) or to both national classification and IPC | | |
| B. FIELDS SEARCHED | | |
| Minimum documentation searched (classification system followed by classification symbols) | | |
| IPC6: H01Q | | |
| Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched | | |
| SE,DK,FI,NO classes as above | | |
| Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) | | |
| C. DOCUMENTS CONSIDERED TO BE RELEVANT | | |
| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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| <input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex. | | |
| * Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family | | |
| Date of the actual completion of the international search | | Date of mailing of the international search report |
| 25 August 1998 | | 31 -08- 1998 |
| Name and mailing address of the ISA: Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86 | | Authorized officer Rune Bengtsson Telephone No. +46 8 782 25 00 |

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 98/00899

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| US | 5006861 | A | 09/04/91 | NONE | | |
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| WO | 9627219 | A1 | 06/09/96 | NONE | | |
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